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(54) **ELECTRONIC ASSEMBLIES WITH SCALABLE CLIP-TYPE CONNECTORS**

(71) Applicants: **Gaurav Chawla**, Tempe, AZ (US); **Joshua D. Heppner**, Chandler, AZ (US); **Jeffory L Smalley**, East Olympia, WA (US); **Vijaykumar Krithivasan**, Chandler, AZ (US)

(72) Inventors: **Gaurav Chawla**, Tempe, AZ (US); **Joshua D. Heppner**, Chandler, AZ (US); **Jeffory L Smalley**, East Olympia, WA (US); **Vijaykumar Krithivasan**, Chandler, AZ (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

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(51) **Int. Cl.**

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H01R 11/24	(2006.01)
H01R 12/72	(2011.01)
H01R 12/88	(2011.01)

(52) **U.S. Cl.**
CPC ***H01R 11/24*** (2013.01); ***H01R 12/721*** (2013.01); ***H01R 12/88*** (2013.01); *Y10T 29/4913* (2015.01)

(58) **Field of Classification Search**
CPC H01R 11/24; H01R 13/15; H01R 11/282; H01R 2201/12
USPC 439/822, 912
See application file for complete search history.

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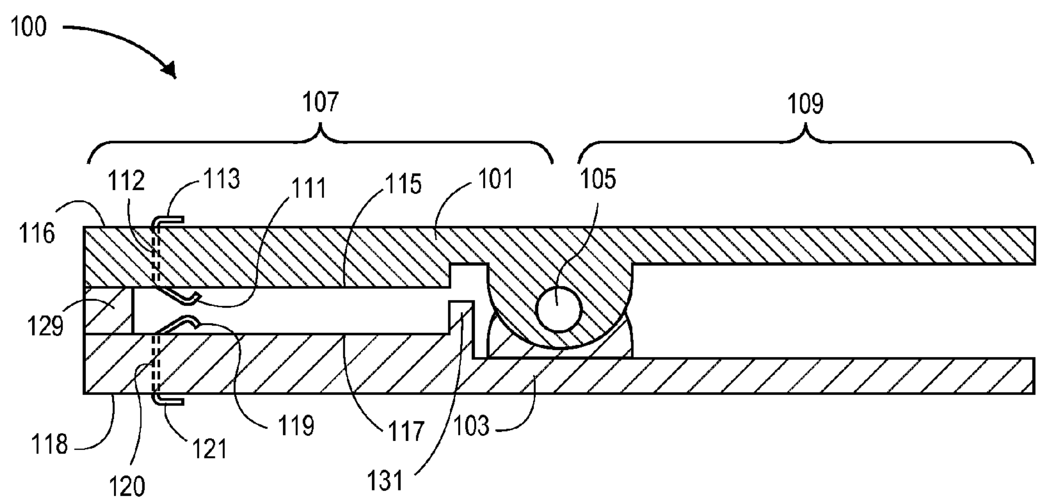
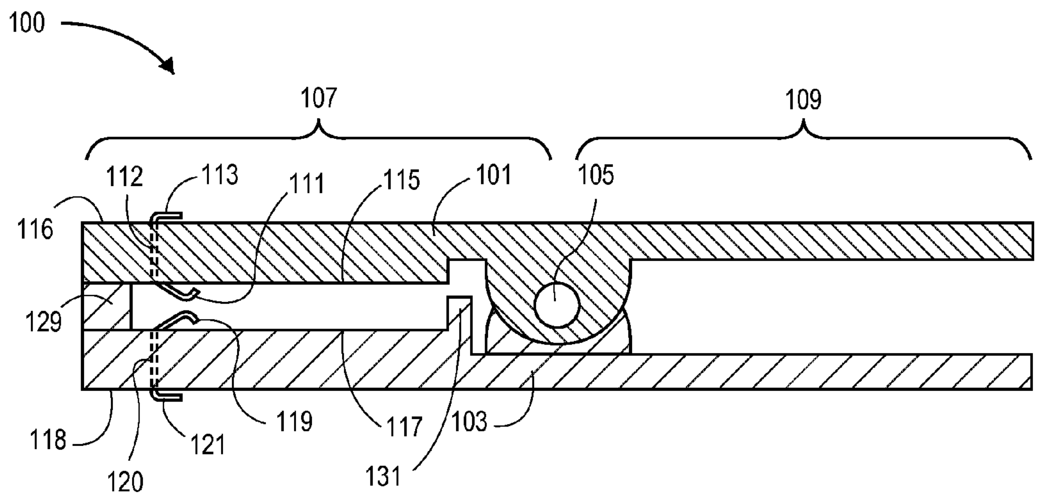
Primary Examiner — Phuong Dinh
(74) *Attorney, Agent, or Firm* — Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

A clip-type connector for electrically coupling a substrate with a device or another substrate is disclosed. An electrical connector comprises a top plate and a bottom plate. An array of contacts are on at least one of the top plate and bottom plate. A hinge is located between the top plate and the bottom plate such that the hinge mechanically connects the top plate to the bottom plate. A spring applying a force against the top and bottom plates.

25 Claims, 12 Drawing Sheets




100
107
109
112
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116
129
118
120
121
119
117
103
131

FIG. 1A

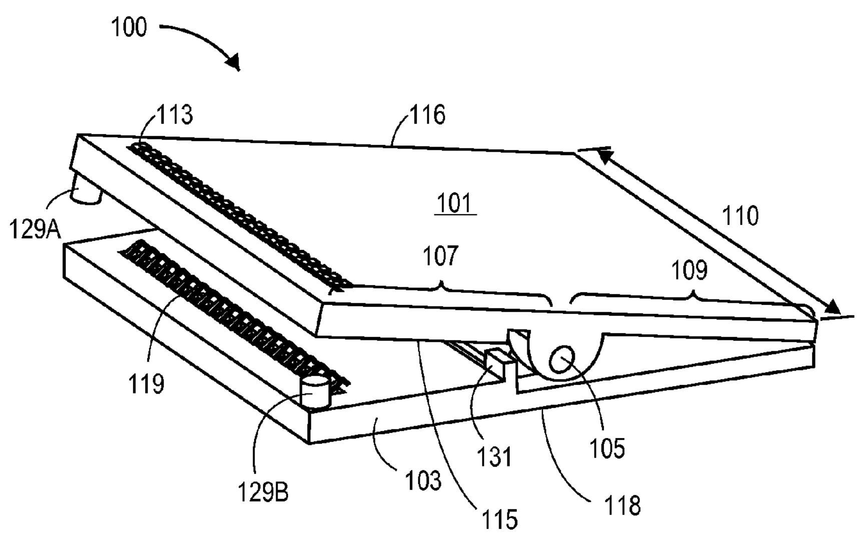

100
113
116
101
110
129A
107
109
119
129B
103
131
105
115
118

FIG. 1B

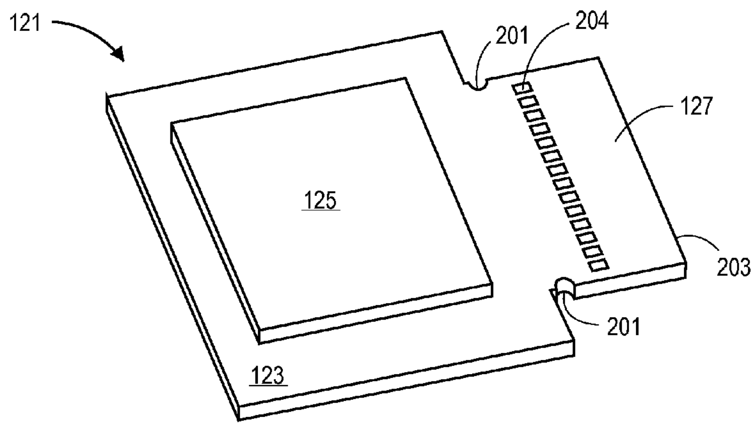

121
201
204
127
125
203
201
123

FIG. 2A

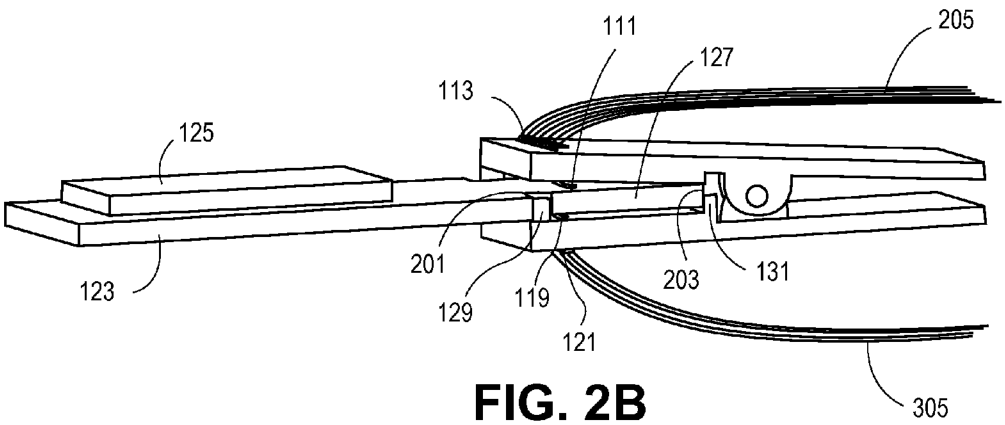

111
205
127
113
125
201
203
131
123
129
119
121
305

FIG. 2B

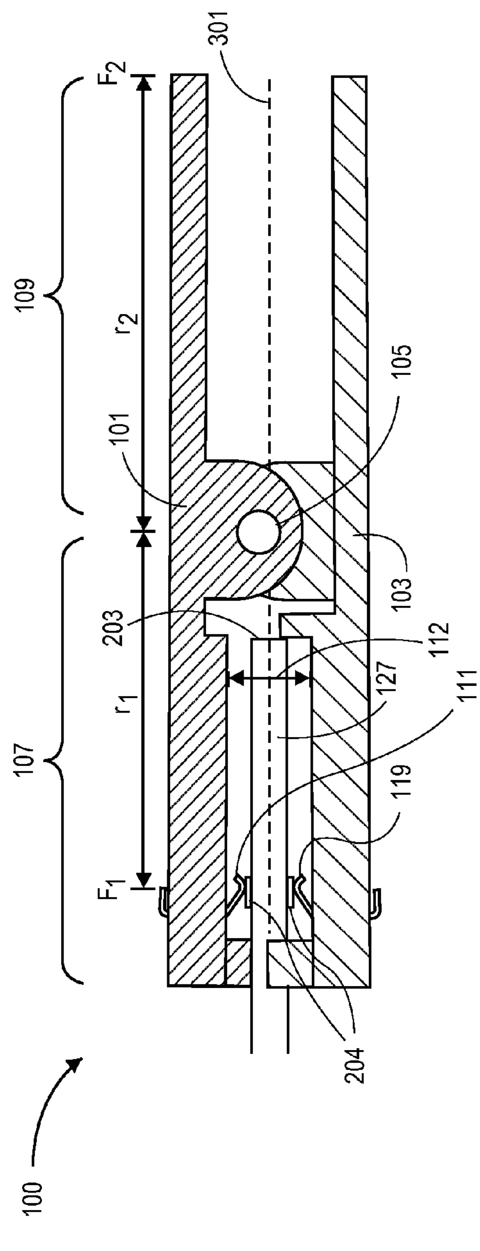

100
107
109
101
105
103
203
112
127
111
119
204
301
F_1
F_2
r_1
r_2

FIG. 3A

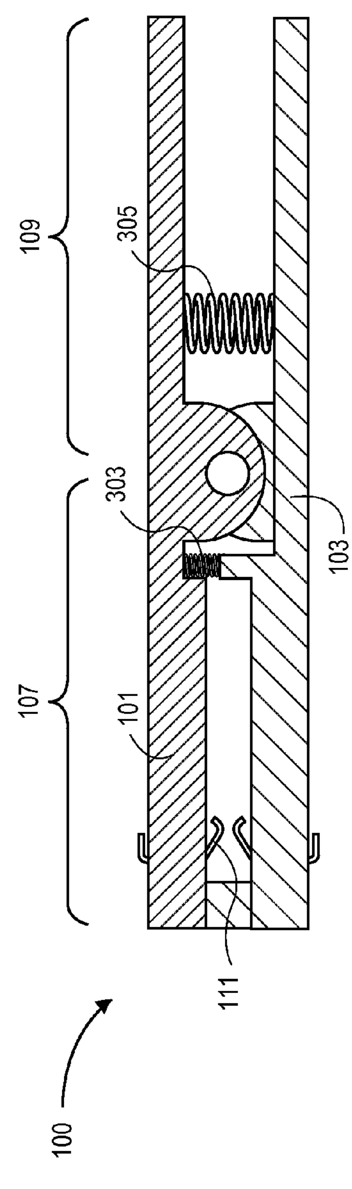
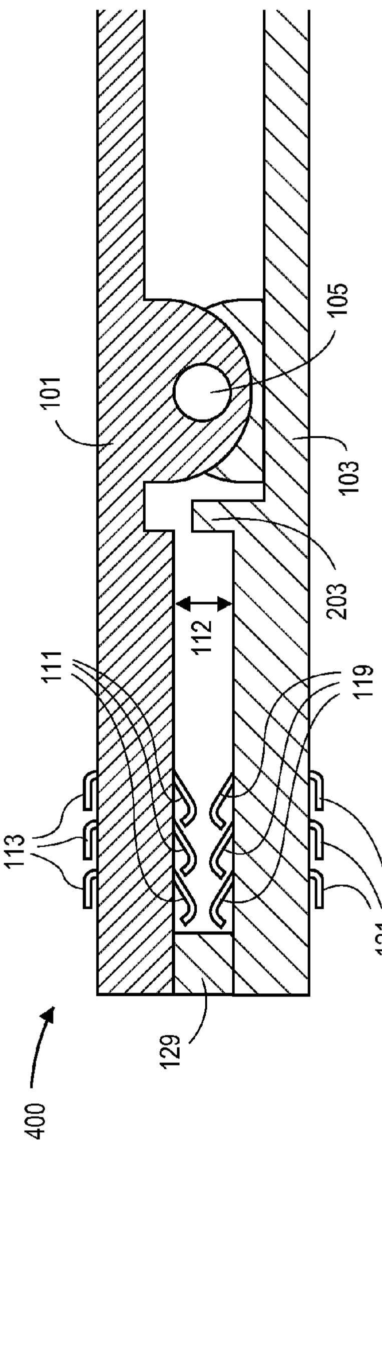
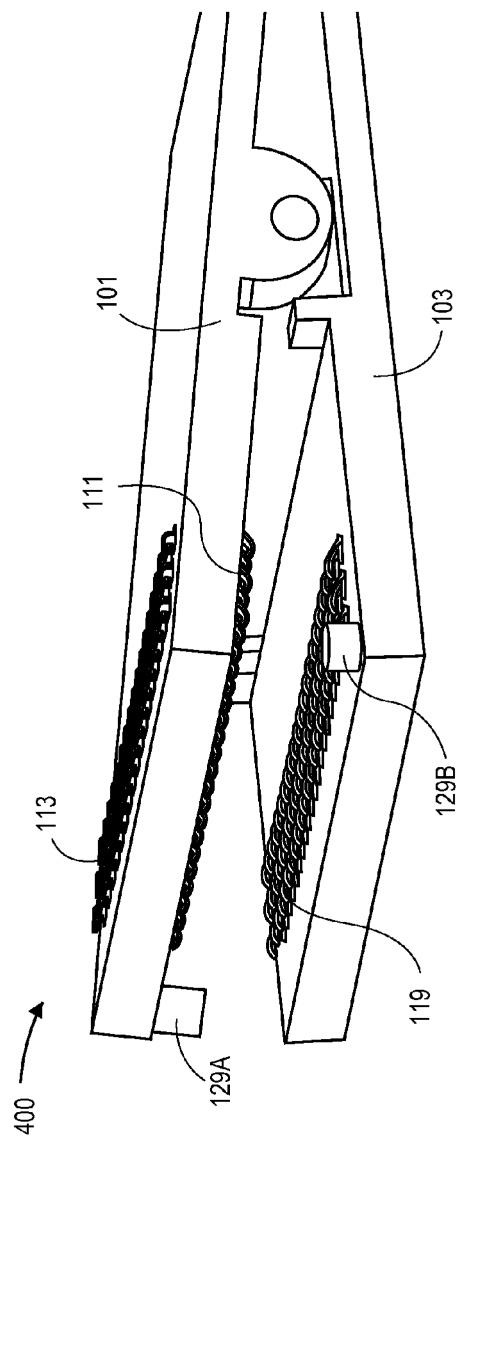

100
107
109
101
103
111
303
305

FIG. 3B



101
105
103
203
112
111
119
113
121
129
400

FIG. 4A



101
103
111
113
129B
119
129A
400

FIG. 4B

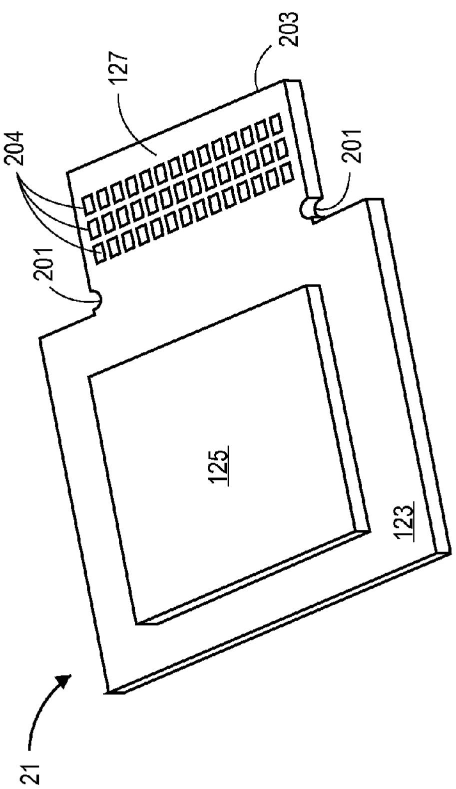

121
123
125
127
201
201
203
204

FIG. 4C

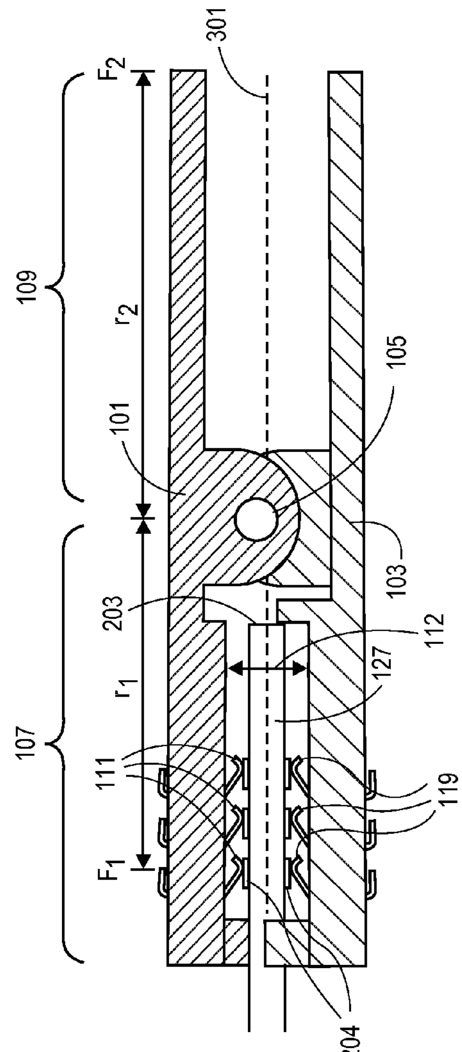

301
F_2
109
r_2
105
101
103
203
112
127
r_1
107
111
119
F_1
204

FIG. 4D

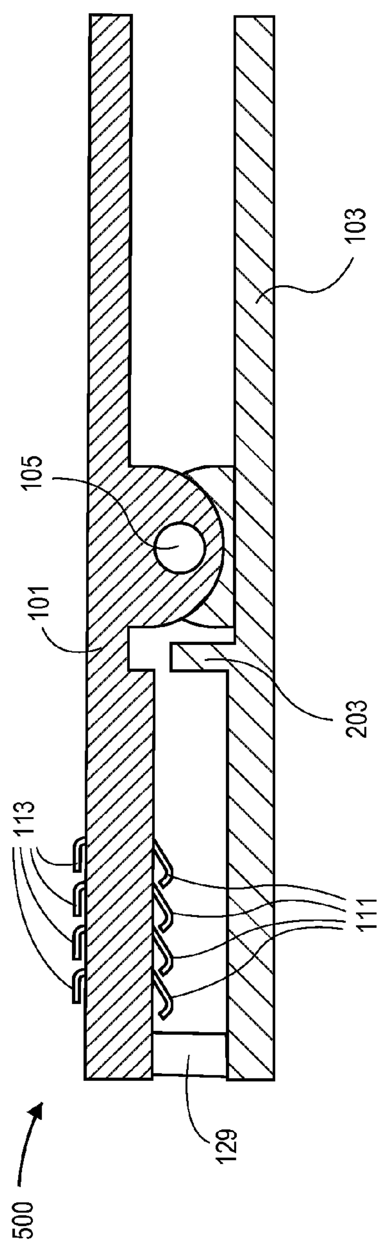


FIG. 5A

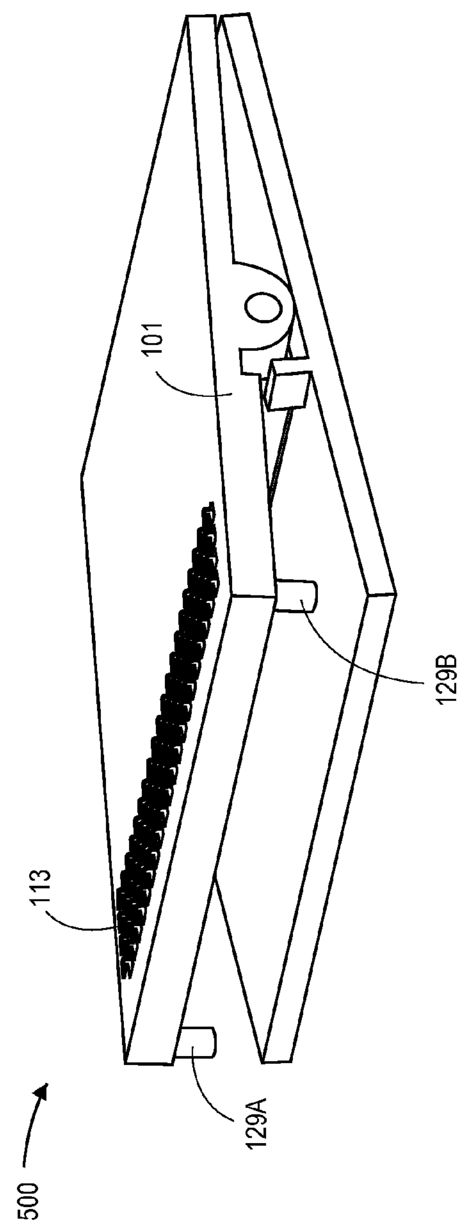


FIG. 5B

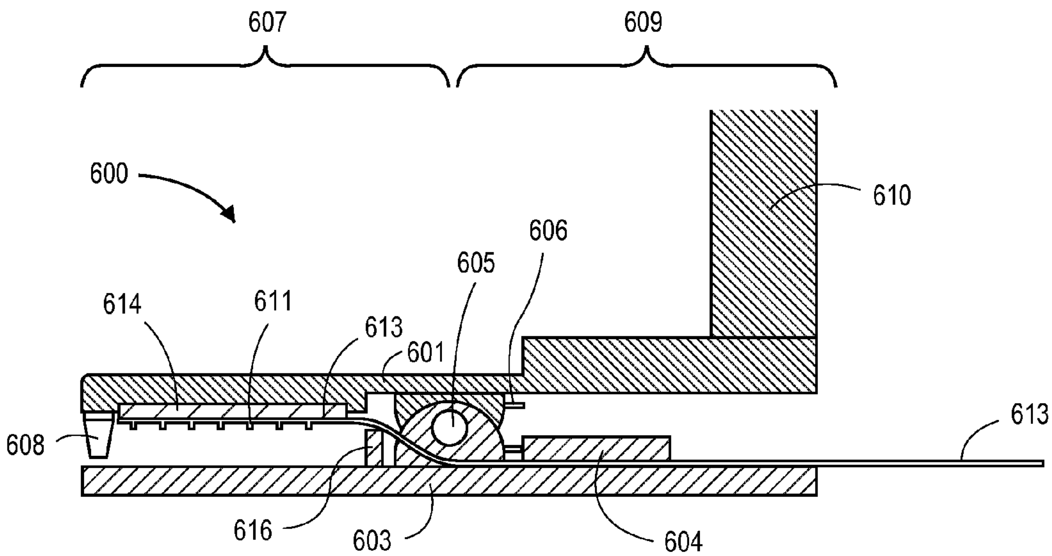

607
609
600
610
606
605
614
611
613
601
608
613
616
603
604

FIG. 6A

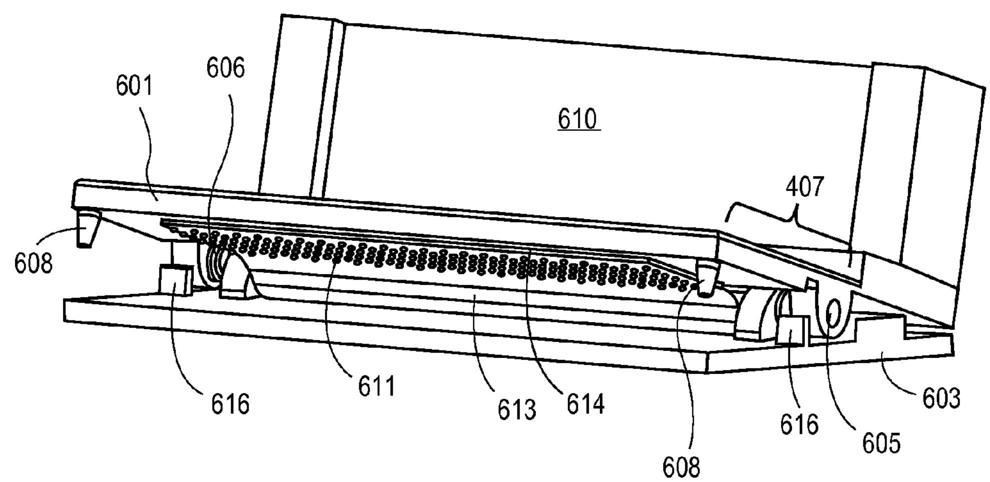

606
601
610
407
608
616
611
613
614
608
616
605
603

FIG. 6B

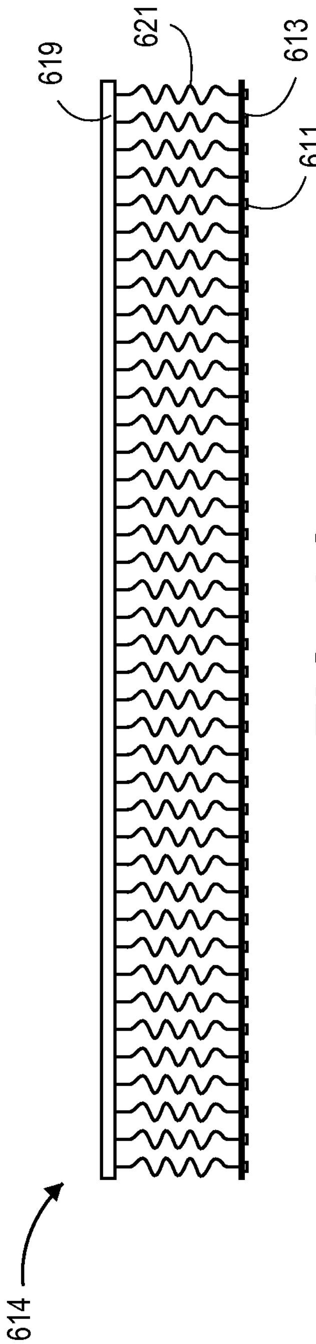


FIG. 6C

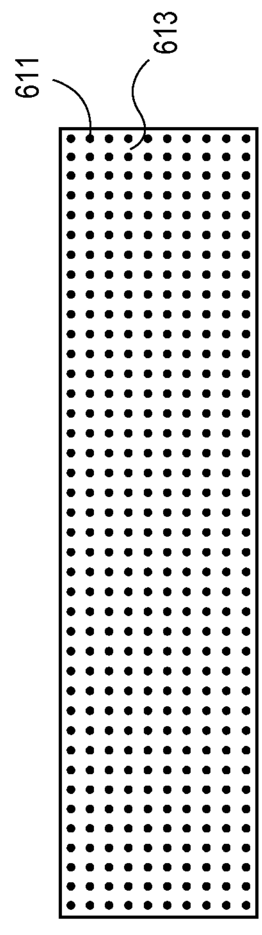


FIG. 6D

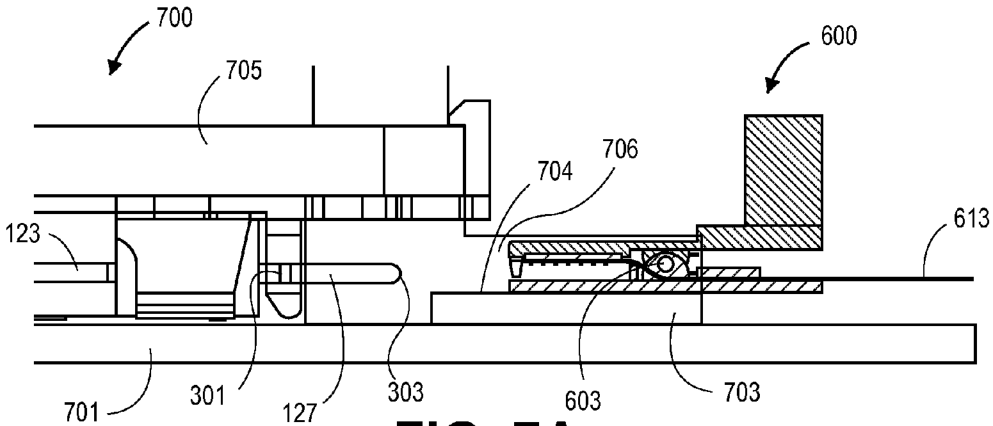


FIG. 7A

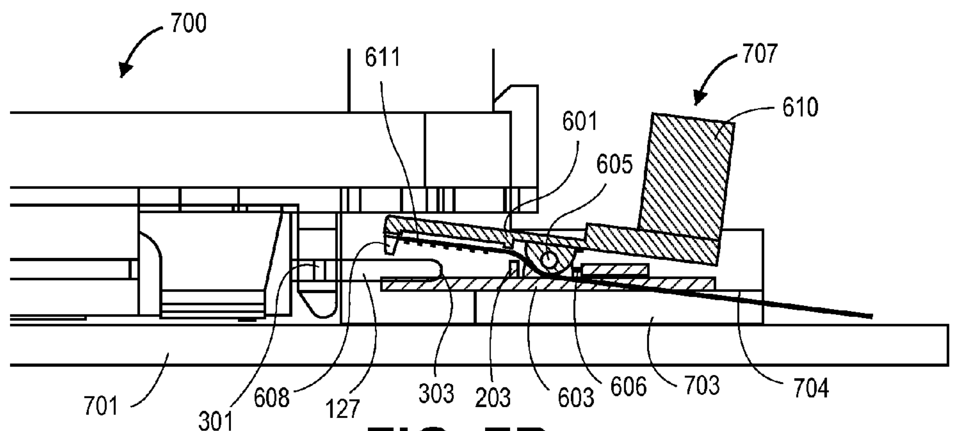


FIG. 7B

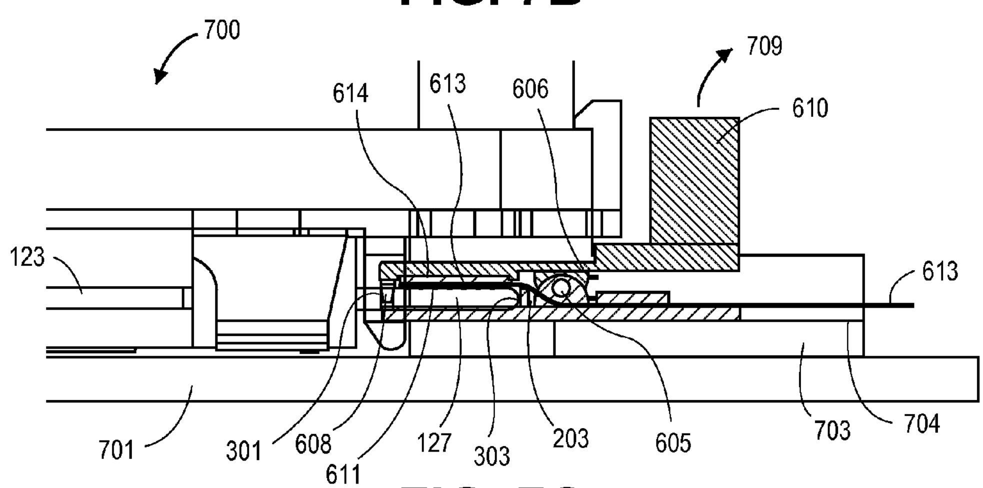


FIG. 7C

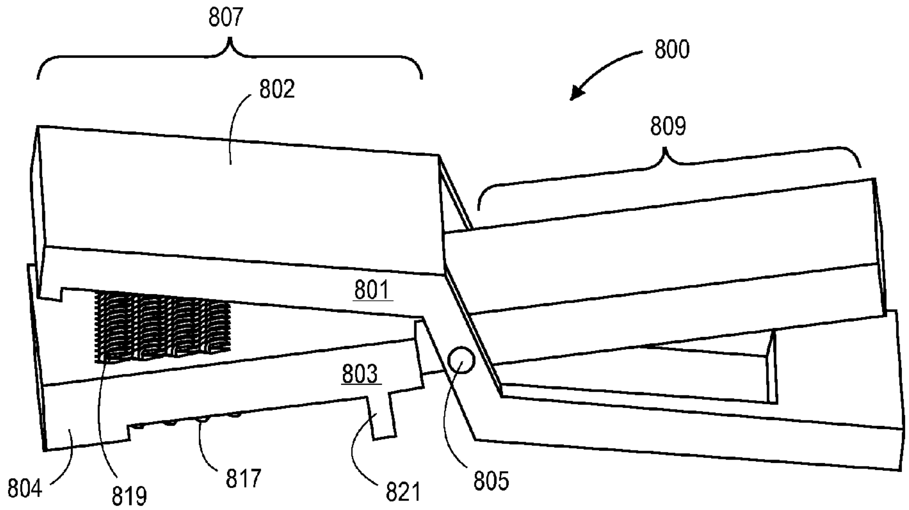

807
800
802
809
801
803
804
819
817
821
805

FIG. 8A

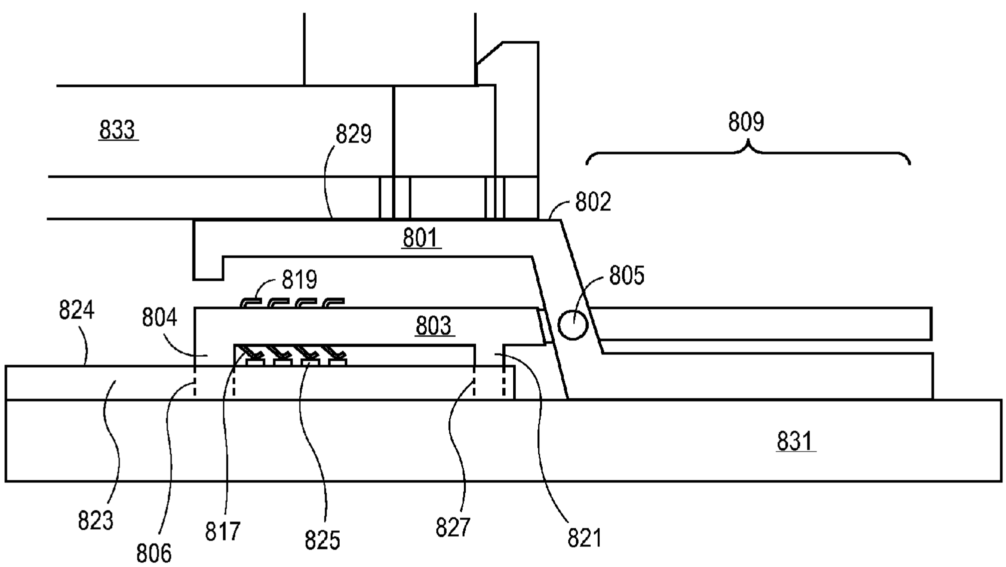
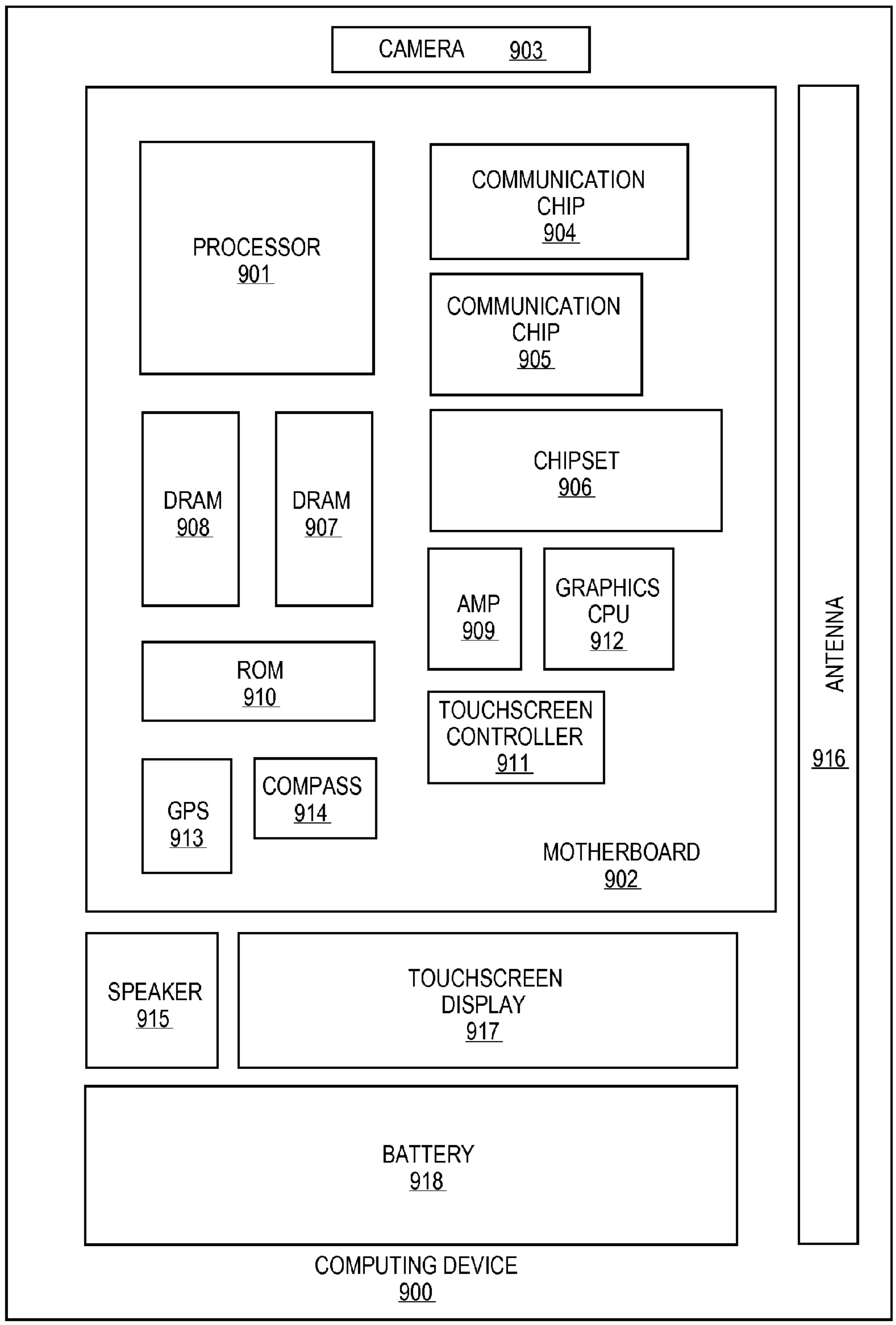

833
829
809
802
801
805
819
824
804
803
831
823
806
817
825
827
821

FIG. 8B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PROCESSOR 901
COMMUNICATION CHIP 904
COMMUNICATION CHIP 905
DRAM 908
DRAM 907
CHIPSET 906
AMP 909
GRAPHICS CPU 912
ROM 910
TOUCHSCREEN CONTROLLER 911
GPS 913
COMPASS 914
MOTHERBOARD 902
ANTENNA 916
SPEAKER 915
TOUCHSCREEN DISPLAY 917
BATTERY 918
COMPUTING DEVICE 900

FIG. 9

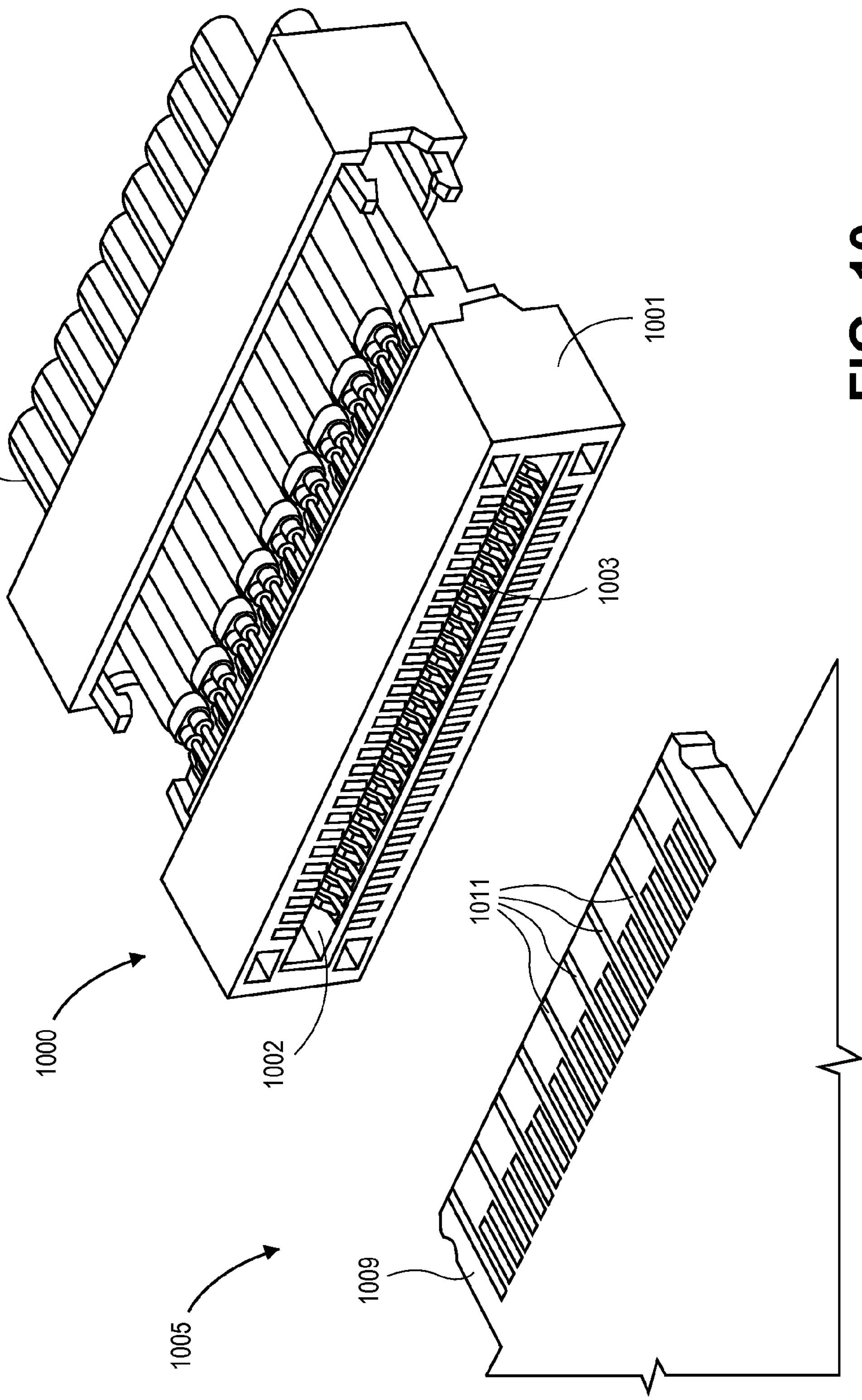

FIG. 10

ELECTRONIC ASSEMBLIES WITH SCALABLE CLIP-TYPE CONNECTORS

TECHNICAL FIELD

Embodiments of the present invention relate generally to edge connectors. More particularly, embodiments of the present invention relate to electronic assemblies with scalable clip-type connectors and connection protrusions.

BACKGROUND

An increasing demand for faster modern computer devices such as mainframe computers, dedicated servers, and desktop computers has reciprocated an increase in demand for faster signal channeling speeds from critical components such as processors, graphics devices, and memory devices. Currently, edge connectors remain the simplest design option of the various connector designs for channeling high-speed signals from computer packages.

As illustrated in FIG. **10**, a conventional edge connector **1000** is formed of a rectangular plastic piece **1001** with an opening **1002** on one side, with contacts **1003** on one or both sides of the opening **1002**, sprung to push into the middle of the opening **1002**. A connection protrusion **1005** is keyed to fit in the opening **1002** of the conventional edge connector **1000**. The connection protrusion **1005** may be part of a printed circuit board (PCB) that protrudes from a side of the PCB and makes connection with the conventional edge connector **1000**. The conventional edge connector **1000** risks contact plating damage when mating with the connection protrusion **1005**. The conventional edge connector's contacts **1003** travel on the connection protrusion's substrate **1009** before reaching the connection protrusion's pads **1011**, thereby leading to possible deterioration of the pads **1011** and contacts **1003** and of any electrical connection between them. As such, connection protrusions **1005** have elongated pads **1011** that extend to the edge of the connection protrusion **1005** upon which the contacts **1003** slide.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A-1B** illustrate a side view and an isometric view of a clip-type connector, in accordance with an embodiment of the invention.

FIG. **2A** illustrates an isometric view of a package with features for mating with a clip-type connector, in accordance with an embodiment of the invention.

FIG. **2B** illustrates an isometric view of an electronic assembly with a clip-type connector, in accordance with an embodiment of the invention.

FIG. **3A** illustrates a side view perspective of a clip-type connector and the specific dimensions that affect its operation, in accordance with an embodiment of the invention.

FIG. **3B** illustrates a clip-type connector with coil springs, in accordance with an embodiment of the invention.

FIGS. **4A-4B** illustrate a scaled clip-type connector with top and bottom contacts, in accordance with an embodiment of the invention.

FIG. **4C** illustrates a package having a scaled diving board to be mated with a clip-type connector, in accordance with an embodiment of the invention.

FIG. **4D** illustrates a scaled clip-type connector with top and bottom contacts engaged in electrical connection with a package substrate, in accordance with an embodiment of the invention.

FIGS. **5A-5B** illustrate a scaled clip-type connector with top contacts, in accordance with an embodiment of the invention.

FIGS. **6A-6B** illustrate a side view and isometric view of a clip-type connector with bump-on-flex compatibility, in accordance with an embodiment of the invention.

FIG. **6C** illustrates a side view perspective of a compliant pad for a clip-type connector with bump-on-flex compatibility, in accordance with an embodiment of the invention.

FIG. **6D** illustrates a top view perspective of an array of contacts on a bump-on-flex cable, in accordance with an embodiment of the invention.

FIGS. **7A-7C** illustrate a method of engaging a clip-type connector with bump-on-flex compatibility to be in electrical connection with a package substrate, in accordance with an embodiment of the invention.

FIGS. **8A-8B** illustrate an inverted clip-type connector with an array of contacts, in accordance with an embodiment of the invention.

FIG. **9** illustrates a computing system implemented with one implementation of the invention.

FIG. **10** illustrates an isometric view of a conventional edge connector and a connection protrusion of a printed circuit board.

DETAILED DESCRIPTION

Electronic assemblies with scalable clip-type connectors and connection protrusions are disclosed. Embodiments of the present invention are described with respect to specific details in order to provide a thorough understanding of the invention. One of ordinary skill in the art will appreciate that embodiments of the invention can be practiced without these specific details. Additionally, the various embodiments shown in the figures are illustrative representations and are not necessarily drawn to scale.

Embodiments of the invention are directed to clip-type connectors. In one embodiment of the invention, a clip-type connector includes a top plate and a bottom plate that are connected together by a hinge. An array of contacts is on at least one of the top and bottom plates. A spring applies force against the top and bottom plates to draw a portion of the top and bottom plates toward one another.

To make electrical connection between the array of contacts and a substrate, the clip-type connector is opened at one end by an applied force. The clip-type connector is then aligned to the substrate to position the substrate in the opened end between the top and bottom plates of the clip-type connector. The force is then removed to close the array of contacts onto the substrate, thus forming an electrical connection. The array of contacts does not travel on the substrate before making contact with the pads.

In an embodiment, the clip-type connector includes locking features that prevent the clip-type connector from inadvertently separating from the substrate after electrical connection has been made. Additionally, in an embodiment, the clip-type connector includes stopping features that prevent the substrate from entering too far into the clip-type connector. Furthermore, flex cables may electrically couple to the clip-type connector, which may then be electrically coupled to the substrate. The clip-type connector enables electrical coupling to a substrate without causing the array of contacts to travel on the substrate. Additionally, the clip-type connector can be scaled according to design requirements.

FIGS. **1A-1B** illustrate a clip-type connector in accordance with an embodiment of the invention. A side view of a clip-type connector **100** in accordance with an embodiment of the invention is illustrated in FIG. **1**A. The clip-type connector **100** includes a top plate **101** and a bottom plate **103** that are mechanically coupled to one another by a hinge **105**. The hinge **105** is located between the top and bottom plates **101** and **103**. The top plate **101** and bottom plate **103** each have an engaging region **107** and a non-engaging region **109** that are separated by the location of the hinge **105**. In an embodiment, the hinge **105** is a spring-loaded hinge that draws the engaging regions **107** of the top and bottom plates **101** and **103**, respectively, toward one another. The engaging region **107** of the top plate **101** includes an array of top contacts **111** on an inner side **115** of the top plate **101**, and an array of top couplers **113** on an outer side **116** of the top plate **101**. Similarly, in an embodiment, the engaging region **107** of the bottom plate **103** includes an array of bottom contacts **119** on an inner side **117** of the bottom plate **103**, and an array of bottom couplers **121** on an outer side **118** of the bottom plate **103**. The couplers **113** and **121** are electrically coupled to the contacts **111** and **119**, respectively. In an embodiment, the each contact **111** and each top coupler **113** are formed from one integrated structure that extends through the top plate **101**, as indicated by the dotted structure **112**. Additionally, in an embodiment, each bottom contact **119** and each bottom coupler **121** are formed from one integrated structure that extends through the bottom plate **103**, as indicated by the dotted structure **120**. In an embodiment, the clip-type connector **100** includes a locking feature **129** that prevents the clip-type connector **100** from inadvertently disengaging from a substrate when engaged. Additionally, in an embodiment, the clip-type connector **100** includes a stopping feature **131** that prevents the substrate from inserting too far into the clip-type connector **100**.

FIG. **1**B illustrates an isometric view of an opened clip-type connector **100** in accordance with an embodiment of the invention. In an embodiment, the arrays of contacts **111** and **119** extend across a portion of a width **110** of the top and bottom plates **101** and **103**, respectively. In an embodiment, the width **110** is the distance that runs along the length of the hinge **105**. As shown in FIG. **1**B, the top and bottom arrays of contacts **111** and **119** extend more than half a distance of the width **110** of the top and bottom plates **101** and **103**, respectively. In an embodiment, a pair of locking features **129** protrudes from the inner sides **115** and **117** of the top and bottom plates **101** and **103**, respectively. In a particular embodiment, a top locking feature **129**A protrudes from the top plate **101** and a bottom locking feature **129**B protrudes from the bottom plate **103**.

FIG. **2**A illustrates an isometric view of a package **121** with features for mating with a clip-type connector in accordance with an embodiment of the invention. In an embodiment, the package **121** includes a package substrate **123** and a die **125**. The die **125** may be a microelectronic device that is constructed from a bulk monocrystalline semiconductor substrate, on top of which are semiconductor devices, metal interconnect layers electrically coupled to the semiconductor devices, a passivation layer disposed over the metal interconnect layers, and finally, contacts exposed in openings in the passivation layer and electrically coupled to the metal interconnect layers. The die **125** may be any device such as, but not limited to, a processor, a graphics device, and a memory device. In an embodiment, the die **125** is flip-chip bonded to the substrate **123** such that the die **125** is electrically coupled with the substrate **123**.

As further depicted in FIG. **2**A, the diving board **127** protrudes from a side of the substrate **123**. In embodiments, the diving board **127** is an extension of the substrate **123** such that the diving board **127** and the substrate **123** form one monolithic substrate. The diving board **127** has an edge **203** that may make contact with the stopping feature **131** of the clip-type connector **100** for alignment and tactile feedback purposes, as will be discussed further below. In an embodiment, the diving board **127** is a connection protrusion. The diving board **127** includes an array of pads **204** that are electrically coupled to the die **125** through redistribution lines (not shown) within, on top, or on bottom of the substrate **123**. In an embodiment, two arrays of pads **204** are located on the diving board **127**, one on the top and one on the bottom, for the top and bottom contacts **111** and **119**, respectively. The array of pads **204** may correspond to the arrays of contacts **111** and **119** on the clip-type connector **100**. In an embodiment, each pad in the array of pads **204** corresponds to a specific contact in one clip-type connector **100**. Alternatively, in an embodiment, a portion of the array of pads **204** correspond to an array of contacts on a first clip-type connector and another portion of the array of pads **204** corresponds to an array of contacts on a second clip-type connector. The array of pads **204** may not extend to the edge **203** of the diving board **127**. In an embodiment, each pad in the array of pads **204** does not extend to the edge **203** of the diving board **127**. As such, the diving board **127**, such as a connection protrusion, may be scaled according to design requirements. Alternatively, in an embodiment, at least one pad extends partially or all the way to the edge **203** of the diving board **127**. In an embodiment, the diving board **127** is scaled such that more than one array of pads **204** are located on one side of the diving board **127**. The diving board **127** may also include locking keys **201**. In an embodiment, the locking keys **201** are notches formed on edges of the diving board **127** into which locking features **129** of the clip-type connector **100** insert.

FIG. **2**B illustrates an isometric view of an electronic assembly with a clip-type connector, in accordance with an embodiment of the invention. In an embodiment, the electronic assembly includes a package electrically connected to an array of cables **205** with a clip-type connector. The package may include a die **125** electrically coupled to a package substrate **123**, and a diving board **127** with pads **204** (as shown in FIG. **2**A). In an embodiment, the array of cables **205** are attached to the top and bottom arrays of couplers **113** and **121**, which electrically couple the array of cables **205** to the top and bottom arrays of contacts **111** and **119**. The array of cables **205** may be any suitable high density electrical transmission line such as, but not limited to, a flex cable, an array of micro coaxial cables, interposer attachments, optical cables, or a substrate material layer embedded with patterned conductive lines. The array of cables **205** may electrically couple the package substrate **123** to a separate device or substrate, such as a printed circuit board (PCB).

When the clip-type connector is engaged in electrical connection with the package substrate **123**, the top and bottom arrays of contacts **111** and **119** are pressed upon their respective arrays of pads **204** on the diving board **127**. In an embodiment, each contact in the top and bottom arrays of contacts **111** and **119** are spring-type contacts, such as but not limited to cantilever contacts and land grid array (LGA)-type contacts. The spring-type contacts substantially minimize relative motion between the arrays of contacts **111** and **119** and the pads **204** on the diving board **127**. As such, physical degradation of the arrays of contacts **111** and **119** as well as degradation of the electrical connection between the arrays of contacts **111** and **119** and the pads **204** are significantly minimized. In an embodiment, the edge **203** of the diving board **127** makes contact with the stopping feature **131**. In an embodiment, the stopping feature **131** has a height that is at least half of a distance between the top and bottom plates **101** and **103**. The stopping feature **131** prevents the diving board **127** from inserting too far into the clip-type connector **100**. Furthermore, in an embodiment, the stopping feature **131** is an alignment structure designed to stop the diving board **127** when the pads **204** are horizontally aligned with the contacts **111** and **119**. The stopping feature **131** may also provide tactile feedback to the user when the diving board **127** bumps into the stopping feature **131**. The tactile feedback may indicate to the user that the clip-type connector **100** is now positioned to allow the arrays of contacts **111** and **119** to contact the pads **204**.

As further illustrated in FIG. **2**B, the locking features **129** of the clip-type connector insert into the locking keys **201** of the diving board **127**. In an embodiment, the locking features **129** prevent the clip-type connector from inadvertently separating from the diving board **127** when the clip-type connector is engaged in electrical connection with the diving board **127**. Additionally, in an embodiment, the locking features **129** help align the clip-type connector to the diving board **127** by fitting into the locking keys **201** when the clip-type connector is aligned with the diving board **127**. In an embodiment, the locking features **129** are taller than the combined height of the tallest contact in each of the arrays of contacts **111** and **119**. As such, the top array of contacts **111** are protected from being damaged by the bottom array of contacts **119**, and vice versa, when the clip-type connector **100** is not connected to the diving board **127** and in a closed position, as shown in FIG. **1**A. In embodiments, the amount of pressure required to be exerted onto the pads **204** by the contacts **111** and **119** may determine the dimensions of the clip-type connector **100**, as discussed in more detail in FIG. **3** below.

FIG. **3**A illustrates a side view perspective of a clip-type connector **100** and the specific dimensions that affect its operation, in accordance with an embodiment of the invention. The clip-type connector **100** includes a spring-loaded hinge **105** in between a top plate **101** and a bottom plate **103**. In an embodiment, the top and bottom plates **101** and **103** are separated by a separation height **112**. The separation height **112** may be adjusted according to the thickness of the diving board **127** so that the contacts **111** and **119** are not overly strained. For example, the separation height **112** may increase when the thickness of the diving board **127** increases. Additionally, the separation height **112** may decrease when the thickness of the diving board **127** decreases. As such, the separation height **112** may allow the contacts **111** and **119** to operate at an ample contact height.

In embodiments, the force F_1 is a spring-generated downward force in an engaging region **107** created by the spring-loaded hinge **105**. The force F_1 is applied at a distance r_1 away from the hinge **105**. The force F_1 presses an array of contacts **111** onto pads **204** on a diving board **127**, causing the contacts **111** to make sufficient electrical connection with the pads **204** on the diving board **127**. The force F_2 is a user-generated downward force in a non-engaging region **109** that creates an opposing upward force in the engaging region **107** against F_1. The force F_2 is applied at a distance r_2 away from the hinge **105**. In embodiments, the clip-type connector **100** is opened by applying a force F_2 to create an opposing upward force in the engaging region **107** that is larger in magnitude than that of force F_1. The forces F_1 and F_2 applied to the top plate **101** may be equal in magnitude, but inverted in direction, to forces applied to the bottom plate **103** due to a substantial symmetry of the clip-type connector **100** across a central horizontal plane **301**. As such, for purposes of simplicity, discussions for FIG. **3** herein relate solely to the dimensions of the top plate **101**, but are understood to be equally applicable to the bottom plate **103**.

The dimensions of the clip-type connector, such as r_1, r_2, and the hinge **105**, can be designed using the magnitude of the forces F_1 and F_2. In embodiments, the magnitude of the force F_1 largely depends on the force requirement of the array of contacts **111**. In one embodiment, each contact in the array of contacts **111** requires an enabling force in the rage of 10-20 grams-force (gf). Accordingly, in an embodiment, the force F_1 is equal to or greater than the cumulative enabling force required by the array of contacts **111**. For example, in an embodiment, for a clip-type connector **100** having an array of 200 contacts where each contact has a 15 gf contact force requirement, the total average force required for F_1 is 6.6 pounds-force (lbf).

Subsequently, the hinge **105** can be designed using the calculated force F_1 and the distance r_1. In embodiments, the moment requirement at the hinge **105** can be calculated by the equation:

$$M_{hinge}=F_1 \times r_1$$

where F_1 is the force requirement and r_1 is the distance of F_1 from the hinge **105**. The moment requirement at the hinge **105** may be not too strong to cause the contacts **111** and **119** to collapse from excessive force and not too weak to allow the clip-type connector to inadvertently open. In one particular embodiment, the moment requirement at the hinge is in the range of 20 to 40 lbf·mm. In an embodiment, r_1 is determined based upon the designed location of the pads **204** on the diving board **127**. For example, r_1 can be the distance between the pads **204** and the edge **203** of the diving board **127**. In an embodiment, r_1 is a distance in the range of 3 to 7 mm. Continuing with the example above, if F_1 is 6.6 lbf and r_1 is 5 mm, the moment required (M_{hinge}) is 33 lbf·mm.

Thereafter, M_{hinge} may be used to design the hinge spring according to techniques well known in the art. The hinge spring may be any suitable type of spring, such as but not limited to, torsion springs and sheet metal springs. In the embodiment depicted in FIG. **3**A, the spring-loaded hinge **105** includes a torsion spring that coils around the hinge **105** and is thus not shown. Alternatively, in an embodiment, tension coil springs and compression coil springs are used to operate the clip-type connector **100**. A clip-type connector **100** utilizing tension and compression coil springs is illustrated in FIG. **3**B.

With brief reference to FIG. **3**B, two coil springs are used in lieu of the torsion spring in the spring-loaded hinge **105** from FIG. **3**A to operate the clip-type connector **100** as illustrated. An engaging coil spring **303** is placed between the top and bottom plates **101** and **103** in the engaging region **107** to apply a constant downward force for the contacts **111**. Additionally, a non-engaging coil spring **305** is placed between the top and bottom plates **101** and **103** in the non-engaging region **109** to help open the clip-type connector **100** by generating a force that pulls the non-engaging region **109** of the top plate **101** downward. In an embodiment, the engaging and non-engaging coil springs **303** and **305** are perpendicularly attached to the top and bottom plates **101** and **103**. It is to be appreciated that any spring or spring design that can apply constant downward force for the array of contacts **111** may be used for the clip-type connector **100**.

Referring now back to FIG. **3**A, once the spring is designed, the distance r_2 may be designed according to the equation:

$$r_2=M_{hinge}/F_2$$

where M_{hinge} is the moment requirement for the spring-loaded hinge **105** and F_2 is the downward force applied on the non-engaging region **109** of the top plate **101**. In an embodiment, the magnitude of the force F_2 is defined by a target value set to enable ergonomic operation of the clip-type connector **100** by hand and/or to prevent user fatigue from repeated use. In an embodiment, the target value for ergonomic operation by hand is in the range of 3 to 5 lbf. Therefore, continuing with the example above once more, if M_{hinge} is 33 lbf·mm and F_2 is 4 lbf, then r_2 is approximately 8 mm. As a result of the equations above, given F_1 and F_2, the clip-type connector **100** can be designed with any dimensions and with any spring-loaded hinge.

FIGS. **4**A-**4**B illustrate a scaled clip-type connector with top and bottom contacts, in accordance with an embodiment of the invention. With reference to FIG. **4**A, a side view perspective of a scaled clip-type connector **400** with top and bottom contacts according to an embodiment of the invention is illustrated. A scaled clip-type connector may have more than one row of contacts. In the embodiment depicted in FIG. **4**A, the scaled clip-type connector **400** has arrays of contacts **111** and **119** that are formed of three rows of contacts. As such, the scaled clip-type connector **400** has 3 times as many rows as a non-scaled clip-type connector, such as a conventional electrical connector **1000** shown in FIG. **10**.

Referring now to FIG. **4**B, an isometric view of the scaled clip-type connector **400** with top and bottom contacts according to an embodiment of the invention is illustrated. In an embodiment, the scaled clip-type connector **400** may have an m×n array of contacts on at least one of the top or bottom plates **101** or **103**, respectively. An m×n array has m number of columns and n number of rows. In the embodiment illustrated in FIG. **4**B, the array of contacts **111** and **119** are formed of a 20×3 array of contacts. In an embodiment, the number of contacts in the top array of contacts **111** is equal to the number of contacts in the bottom array of contacts **119**. In an embodiment, the arrangement of the top array of contacts **111** is identical to the arrangement of the bottom array of contacts **119**. Alternatively, in an embodiment, the number of contacts in the top array of contacts **111** is different than the number of contacts in the bottom array of contacts **119**. Furthermore, in an embodiment, the arrangement of the top array of contacts **111** is different than the arrangement of the bottom array of contacts **119**. For example, the number of contacts in each row of the top array of contacts **111** may change row by row, whereas the number of contacts in each row of the bottom array of contacts **119** may not change. It is to be appreciated that any combination or arrangement of contacts between and within the top and bottom arrays of contacts **111** and **119** are envisioned in embodiments of the invention.

FIG. **4**C illustrates a package **121** having a scaled diving board **127** to be mated with the clip-type connector illustrated in FIG. **4**B. In an embodiment, the scaled diving board **127** is a scaled connection protrusion. The scaled diving board **127** may have an m×n array of pads **204** that matches with the m×n array of contacts **111** and/or **119**. As such, in an embodiment, each pad in the array of pads **204** corresponds to a specific contact in the array of contacts **111** and/or **119**, as shown in FIG. **4**D. In FIG. **4**D, the scaled clip-type connector **400** engaged in electrical connection with the package with the scaled diving board **127** is illustrated in accordance with an embodiment of the invention. The contacts **111** and **119** are each in contact with respective pads **204** on the diving board **127**. In an embodiment, the separation height **112** is configured to allow even pressure to be applied across the m×n array of contacts **111** and **119** onto the m×n array of pads **204**.

FIGS. **5**A-**5**B illustrate a scaled clip-type connector with top contacts, in accordance with an embodiment of the invention. With reference to FIG. **5**A, a side view perspective of a scaled clip-type connector **500** with top contacts according to an embodiment of the invention is illustrated. The top plate **101** includes a scaled array of contacts **111**. In an embodiment, as shown in FIG. **5**A, the scaled array of contacts **111** is formed of four rows of contacts. As such, the scaled clip-type connector **500** has four times as many rows of contacts as a non-scaled clip-type connector with only one row of contacts, such as the conventional electrical connector **1000** shown in FIG. **10**. Although the embodiment in FIG. **5**A illustrates a top plate **101** having an array of contacts **119** while the bottom plate **103** does not, in an embodiment, the bottom plate **103** has an array of contacts and the top plate **101** does not. Referring now to FIG. **5**B, an isometric view of the scaled clip-type connector with top contacts according to an embodiment of the invention is illustrated. The bottom plate **103** does not have any contacts and may be smooth. The locking features **129**A and **129**B may both be located on the top plate **101** to protect the top contacts **111**, as the bottom plate **103** does not have any contacts that need to be protected. In an embodiment, the locking features **129**A and **129**B are each taller than the top contacts **111** to protect the top contacts from damage caused by unintentional contact with a substrate.

FIGS. **6**A-**6**B illustrate a side view and an isometric view of a clip-type connector with bump-on-flex compatibility, in accordance with an embodiment of the invention. The clip-type connector with bump-on-flex compatibility is capable of electrically coupling a flex cable having an array of contact bumps to a package substrate. Accordingly, the package substrate may be electrically coupled with a separate device or substrate, such as a PCB, through the flex cable or an array of coaxial cables electrically connected to the flex cable. Currently, package substrates are electrically coupled to a PCB through a solder bump arrangement or an LGA-type connection arrangement, which have a maximum data transfer rate in the range of 8 to 12 Gb/s due to surface area constraints. Bump-on-flex cables, on the other hand, are not significantly limited by such surface area constraints. As such, in an embodiment, flex cables can operate at data transfer rates greater than 20 Gb/s. Therefore, for high-speed applications such as high-volume processing or high-speed memory access, bump-on-flex cables may be preferred over conventional solder bump or LGA-type connections.

Referring now to FIG. **6**A, a clip-type connector **600** with bump-on-flex compatibility includes a top plate **601** and a bottom plate **603** mechanically coupled to one another by a spring-loaded hinge **605**. The spring-loaded hinge **605** is located between the top and bottom plates **601** and **603**. The top plate **601** and bottom plate **603** each have an engaging region **607** and a non-engaging region **609** that are separated by the location of the hinge **605**. In the embodiment depicted in FIG. **6**A, a plate extension **610** extends from the non-engaging region **609** of the top plate **101**. The plate extension **610** elevates the location where force (such as F_2 from FIG. **3**A) is applied for ease of access purposes when space is limited, such as when the clip-type connector **600** is positioned near a heat sink. In an embodiment, the spring-loaded hinge **605** includes a spring **606**, such as a torsional spring, that draws the engaging regions **607** of the top and bottom plates **601** and **603** toward one another. In an embodiment, the spring **606** is secured to the clip-type connector **600** by a spring securer **604**. The top plate **601** also includes a locking feature **608** and a stopping feature **616** for reasons disclosed above.

As shown in FIG. **6**A, the engaging region **607** of the top plate **601** is attached to a bump-on-flex cable **613**. In an embodiment, the bump-on-flex cable **613** extends from the engaging region **607**, through the non-engaging region **609**, and out of the clip-type connector **600**. The bump-on-flex cable **613** may tuck underneath the hinge **605** and thread through the gap between the hinge **605** and the bottom plate **603**. In an embodiment, an array of micro coaxial cables electrically connect with the bump-on-flex cable **613** at the end outside of the clip-type connector **600**. An array of contacts **611** are disposed on a portion of the bump-on-flex cable **613** within the engaging region **607**. In an embodiment, the contacts **611** are disposed on an end of the bump-on-flex cable **613** opposite of the end connected to the array of micro coaxial cables. In an embodiment, the contacts **611** are copper cylinders, or any other suitable conductive structures, such as solder bumps, that are electrically coupled to respective wires in the flex cable **613**. The contacts **611** act as both a mechanical and electrical interface for the bump-on-flex cable **613**. Bump-on-flex cables provide a substantially short electrical path to the signal, resulting in significantly lower electrical resistance and cross talk. However, achieving consistent minimum force required to enable electrical connection with a surface proves difficult because of the minimal mechanical compliance of the bumps. To mitigate such difficulty, a compliant mattress **614** may be located between the bump-on-flex cable **613** and the top plate **101**, directly above the contacts **611**. In an embodiment, the compliant mattress **614** is a foam pad, a spring mattress, or any other structure that can apply conformal pressure on uneven surfaces. The compliant mattress may be attached between the top plate **601** and the bump-on-flex cable **613** by any suitable attachment method, such as but not limited to, adhesives, screws, pins, or a combination thereof. The compliant mattress **614** may compensate for variation in bump height caused by package substrate warpage and/or manufacturing non-coplanarity to enable the array of contacts **611** to apply even pressure to a substrate. The specific structure of a spring mattress will be discussed further below.

FIG. **6**B illustrates an isometric view of an opened clip-type connector **600** with bump-on-flex compatibility according to an embodiment of the invention. The bump-on-flex cable **613** is secured to the engaging region **407** of the top plate **601** with a compliant mattress **614**. The compliant mattress **614** is located between the bump-on-flex cable **613** and the top plate **601**, and above the array of contacts **611**. As shown in FIG. **6**B, in an embodiment, the array of contacts **611** on the flex cable **613** spans across greater than half the distance of a width of the top plate **601**. In an embodiment, the width is the distance that runs parallel to the hinge **105**. The width of the flex cable **613** may widen or narrow depending on design, and the arrangement of the contacts **611** may scale accordingly. In an embodiment, the width of the flex cable **613** is not wider than the width of the plate to which it is attached.

FIGS. **6**C-**6**D illustrate an enlarged view of a spring mattress and bump-on-flex arrangement according to embodiment of the invention. FIG. **6**C illustrates a side view perspective of a compliant mattress **614** designed as a spring mattress for a clip-type connector with bump-on-flex compatibility, in accordance with an embodiment of the invention. In an embodiment, the spring mattress includes an array of springs **621** perpendicularly attached between a pressure plate **619** and a flex cable **613**. In an embodiment, the pressure plate is a separate, rigid plate that is attached to the top plate **601**. Alternatively, in an embodiment, the pressure plate **619** is the top plate **601** itself. The pressure plate provides a structural foundation for the springs **621**. The flex cable **613** has an array of contacts **611** for making electrical connection with a substrate. Each spring **621** may be located behind a contact **611** to allow the contact to traverse in a vertical direction. As such, the contact **611** may conform to any unevenness on the substrate or from any variation in contact size to apply equal pressure to each pad on the substrate. In an embodiment, each spring **621** allows the contact **611** to travel a vertical distance of up to 1 mm.

With reference now to FIG. **6**D, a top view perspective of the contact arrangement of a bump-on-flex cable is illustrated. In an embodiment, the contacts **611** on the flex cable **613** are arranged in an m×n array. For example, as shown in the embodiment depicted in FIG. **6**D, the array of contacts **611** is in a 10×40 arrangement. Other embodiments, however, are not limited to such arrangements, and may have scaled rows and/or columns according to design.

FIGS. **7**A-**7**C illustrate a method of connecting a clip-type connector with bump-on-flex compatibility to a package substrate, in accordance with an embodiment of the invention. As shown in FIG. **7**A, in an embodiment, the clip-type connector **600** with bump-on-flex compatibility is setting up for connection to a package **700**. The package **700** may include a package carrier **701**, an alignment guide **703**, a package substrate **123** with a diving board **127**, a die (such as die **125** from FIG. **2**A not shown here) electrically coupled to the package substrate **123**, and a heat sink **705**. The package carrier **701** may be a foundation structure that supports structures layered upon it, such as the heat sink **705**, the package substrate **123**, and the die. In an embodiment, the alignment guide **703** is an elevated structure with a flat top surface **704** and alignment walls **706** on each side. The alignment guide **703** may be used for coarse alignment of the clip-type connector **600** to the diving board **127** in the x, y, and z direction. As shown in FIG. **7**A, the clip-type connector **600** initially rests upon the top surface **704** of the alignment guide **703** and between the alignment walls **706**.

Next, as illustrated in FIG. **7**B, a force **707**, such as force F_2 in FIG. **3**A, is applied on the plate extension **610** to open the clip-type connector **600** as described in FIG. **3**A above. The top and bottom plates **601** and **603** pivot at the spring-loaded hinge **605** such that the locking features **608** and contacts **611** raise above the height of the diving board **127**. Thereafter, the clip-type connector **600** slides on the top surface **704** of the alignment guide **703** toward the package **700**. Because the locking features **608** and the contacts **611** have been raised above the diving board **127**, the locking feature **608** and the contacts **611** do not travel on the diving board **127**. Once the edge **303** of the diving board **127** makes contact with the stopping feature **203**, tactile feedback is given in the form of a collision, which triggers release of the force **707**.

In FIG. **7**C, the clip-type connector **600** is engaged in electrical connection with the package substrate **123**. When the force is unapplied **709**, the spring-loaded hinge **605** draws the contacts **611** onto respective pads on the diving board **127**. Due to the compliant mattress **614**, the contacts **611** apply significantly even pressure against each pad on the diving board **127** despite any surface unevenness on the diving board **127** or difference in coplanarity across the contacts **611**. In addition, the locking features **608** on the top plate **601** slide into the locking keys **301** on the diving board **127**. Once the locking features **608** are set, the clip-type connector **600** is not able to be separated from the diving board **127** without reapplying the force **707**. As such, the package substrate **123**, including all electrical devices electrically coupled with it, such as the die **125**, is now electrically coupled with the flex cable **613**. In an embodiment, the flex cable **613** is connected to an array of micro coaxial cables, which are then connected to another device or substrate, such as a PCB.

FIGS. **8**A-**8**B illustrate an inverted clip-type connector with an array of contacts, in accordance with an embodiment of the invention. In an embodiment, the inverted clip-type connector repels an engaging region of a top plate and a bottom plate away from one another. The inverted clip-type connector may be suitable for situations where a package substrate does not have enough space underneath for the bottom plate to fit.

FIG. **8**A illustrates an isometric view of an inverted clip-type connector **800** with an array of contacts **817**, in accordance with an embodiment of the invention. The inverted clip-type connector **800** has a top plate **801** that crosses with a bottom plate **803** at a spring-loaded hinge **805**. The spring-loaded hinge **805** mechanically connects the top plate **801** with the bottom plate **803**. The inverted clip-type connector **800** has an engaging region **807** and a non-engaging region **809** that are separated by the spring-loaded hinge **805**. In an embodiment, the spring-loaded hinge **805** repels the top and bottom plates **801** and **803** away from one another. The bottom plate **803** has an array of contacts **817** protruding downwards and an array of couplers **819** protruding upwards. The array of contacts **817** may be scaled and spring-typed as disclosed above. In an embodiment, the contacts **817** are electrically coupled to the couplers **819**, which may be electrically coupled to a flex cable to electrically couple the contacts **817** to another device or a PCB. An aligning feature **821** protrudes downward from the bottom plate **803** of the inverted clip-type connector **800** to help align the connector **800** to a substrate. Furthermore, a locking feature **804** protrudes downward from the bottom plate **803** to secure the connector **800** from inadvertently separating from a substrate.

FIG. **8**B illustrates a side view perspective of an inverted clip-type connector **800** engaged in electrical connection with a package substrate **823** having an array of pads **825**. In the depicted embodiment, the package substrate **823** is directly on a package carrier **831**. Accordingly, there is no space for a bottom plate from a clip-type connector to fit. As such, the inverted clip-type connector **800** is used as shown in FIG. **8**B. Pressure is applied to the array of pads **825** by the spring-loaded hinge **805**. The spring-loaded hinge **805** may use any suitable surface to create a reaction force to press the array of contacts **817** on the array of pads **825**. In an embodiment, the spring-loaded hinge **805** uses a bottom surface **829** of a heat sink **833** to create a reaction force for the array of contacts **817** to press against the array of pads **825**. To engage the inverted clip-type connector **800** with the substrate **823**, force (such as force F_2 in FIG. **3** above) is applied to close inverted clip-type connector **800**. The connector **800** is then inserted into the space between the package substrate **823** and the heat sink **829**. When the aligning feature **821** is inserted into an alignment key **827**, the force is then unapplied to engage the inverted clip-type connector **800**. Locking features **804** then fit into locking keys **806** within the package substrate **823** to prevent the inverted clip-type connector **800** from inadvertently separating from the package substrate **823**. The array of contacts **817** are electrically coupled to the array of pads **825**.

FIG. **9** illustrates a computing system **900** implemented with one implementation of the invention. The computing device **900** houses a board **902**. The board **902** may include a number of components, including but not limited to a processor **904** and at least one communication chip **906**. The processor **904** is physically and electrically coupled to the board **902**. In some implementations the at least one communication chip **906** is also physically and electrically coupled to the board **902** with a clip-type connector. In further implementations, the communication chip **906** is part of the processor **904**.

Depending on its applications, computing device **900** may include other components that may or may not be physically and electrically coupled to the board **902**. These other components include, but are not limited to, volatile memory (e.g., DRAM), non-volatile memory (e.g., ROM), flash memory, a graphics processor, a digital signal processor, a crypto processor, a chipset, an antenna, a display, a touchscreen display, a touchscreen controller, a battery, an audio codec, a video codec, a power amplifier, a global positioning system (GPS) device, a compass, an accelerometer, a gyroscope, a speaker, a camera, and a mass storage device (such as hard disk drive, compact disk (CD), digital versatile disk (DVD), and so forth).

The communication chip **906** enables wireless communications for the transfer of data to and from the computing device **900**. The term "wireless" and its derivatives may be used to describe circuits, devices, systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a non-solid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. The communication chip **906** may implement any of a number of wireless standards or protocols, including but not limited to Wi-Fi (IEEE 802.11 family), WiMAX (IEEE 802.16 family), IEEE 802.20, long term evolution (LTE), Ev-DO, HSPA+, HSDPA+, HSUPA+, EDGE, GSM, GPRS, CDMA, TDMA, DECT, Bluetooth, derivatives thereof, as well as any other wireless protocols that are designated as 9G, 4G, 5G, and beyond. The computing device **900** may include a plurality of communication chips **906**. For instance, a first communication chip **906** may be dedicated to shorter range wireless communications such as Wi-Fi and Bluetooth and a second communication chip **906** may be dedicated to longer range wireless communications such as GPS, EDGE, GPRS, CDMA, WiMAX, LTE, Ev-DO, and others.

The processor **904** of the computing device **900** includes an integrated circuit die packaged within the processor **904**. In some implementations of the invention, the processor is electrically coupled to another device or the printed circuit board by a clip-type connector, in accordance with implementations of the invention. The term "processor" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory.

The communication chip **906** also includes an integrated circuit die packaged within the communication chip **906**. In accordance with another implementation of the invention, the integrated circuit die of the communication chip is electrically coupled to another device or a printed circuit board with a clip-type connector in accordance with implementations of the invention.

In further implementations, another component housed within the computing device **900** may be electrically coupled to another device or a printed circuit board with a clip-type connector in accordance with implementations of the invention.

In various implementations, the computing device **900** may be a laptop, a netbook, a notebook, an ultrabook, a smartphone, a tablet, a personal digital assistant (PDA), an ultra mobile PC, a mobile phone, a desktop computer, a server, a printer, a scanner, a monitor, a set-top box, an entertainment control unit, a digital camera, a portable music player, or a digital video recorder. In further implementations, the computing device **900** may be any other electronic device that processes data.

In an embodiment, an electrical connector includes a top plate; a bottom plate; an array of contacts on at least one of the top plate and bottom plate; a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate; and a spring applying a force against the top and bottom plates. Additionally, in an embodiment, the force draws an engaging region of the top plate toward an engaging region of the bottom plate. Furthermore, in an embodiment, the force repels an engaging region of the top plate away from an engaging region of the bottom plate. Moreover, in an embodiment, the array of contacts comprises copper cylinders on a bump-on-flex cable. In one embodiment, the array of contacts is a spring-type contact. Furthermore, in one embodiment, the spring-type contact is a cantilever contact. Additionally, in one embodiment, the spring is located in the hinge, forming a spring-loaded hinge. In an embodiment, the spring is a spring selected from the group consisting of a torsional spring and a sheet metal spring. Moreover, in an embodiment, the spring comprises a pair of linear springs between the top and bottom plates on either side of the hinge perpendicularly connected to the top and bottom plates. Additionally, in an embodiment, the top plate comprises a top locking feature. Furthermore, in an embodiment, the bottom plate comprises a bottom locking feature. In one embodiment, the bottom plate comprises a stopping feature.

In an embodiment, an electronic assembly includes a package comprising a die electrically coupled to a substrate, the substrate comprising a diving board that protrudes from an edge of the substrate; an electrical connector electrically coupled to the substrate through the diving board, the electrical connector comprising: a top plate, a bottom plate, an array of contacts on at least one of the top plate and bottom plate, a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate, and a spring applying a force against the top and bottom plates; and a cable electrically coupled to the electrical connector, the electrical connector is electrically coupled to the substrate. Additionally, in an embodiment, the substrate is a package substrate. Moreover, in an embodiment, the diving board comprises an array of pads, each pad of the array of pads does not extend to an edge of the diving board. Furthermore, in an embodiment, the edge of the diving board contacts a stopping feature on the electrical connector. In one embodiment, the diving board comprises a locking key. Additionally, in one embodiment, the locking key is a notch formed at an edge of the diving board into which a locking feature on the electrical connector fits. Moreover, in one embodiment, the cable is a flex cable. In an embodiment, the flex cable comprises an array of contacts on a first end of the flex cable. Additionally, in an embodiment, the electronic assembly further includes a compliant mattress disposed behind the array of contacts and between the flex cable and at least one of the top and bottom plate. Furthermore, in an embodiment, the flex cable is electrically coupled to a coaxial cable at a second end of the flex cable, the second end is opposite of the first end. Moreover, in an embodiment, the force draws an engaging region of the top plate towards an engaging region of the bottom plate.

In an embodiment, a method of forming an electronic assembly includes providing a package comprising a die electrically coupled to a substrate, the substrate comprising a diving board that protrudes from an edge of the substrate; providing an electrical connector comprising: a top plate, a bottom plate, an array of contacts on at least one of the top plate and bottom plate, a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate, and a spring applying a force against the top and bottom plates; applying force upon a non-engaging region of the electrical connector; aligning the electrical connector and the diving board to one another; and removing the force, causing electrical coupling between the electrical connector and the substrate. Additionally, in an embodiment, the array of contacts do not travel on the substrate. Furthermore, in an embodiment, applying the force causes an engaging end of the electrical connector to open. Moreover, in an embodiment, applying the force causes an engaging end of the electrical connector to close. In one embodiment, the electrical coupling is created by a closing force generated by a spring in the electrical connector. Additionally, in one embodiment, aligning the electrical connector includes inserting a locking feature into a locking key. Furthermore, in one embodiment, aligning the electrical connector includes the substrate contacting a stopping feature on the electrical connector.

In utilizing the various aspects of this invention, it would become apparent to one skilled in the art that combinations or variations of the above embodiments are possible for electrically coupling a semiconductor die to another device or a printed circuit board with a clip-type connector. Although embodiments of the present invention have been described in language specific to structural features and/or methodological acts, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features or acts described. The specific features and acts disclosed are instead to be understood as particularly graceful implementations of the claimed invention useful for illustrating embodiments of the present invention.

What is claimed is:

1. An electrical connector, comprising:

a top plate, the top plate having a top surface and an opposite bottom surface;

a bottom plate, the bottom plate having a top surface and an opposite bottom surface, the top surface of the bottom plate facing the bottom surface of the top plate;

an array of contacts on at least one of the top plate and bottom plate, wherein the array of contacts extends from the top surface to the bottom surface of the at least one of the top plate and bottom plate;

a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate; and

a spring applying a force against the top and bottom plates.

2. The electrical connector of claim **1**, wherein the force draws an engaging region of the top plate toward an engaging region of the bottom plate.

3. The electrical connector of claim **1**, wherein the array of contacts comprises copper cylinders on a bump-on-flex cable.

4. The electrical connector of claim **1**, wherein the array of contacts is a spring-type contact.

5. The electrical connector of claim **4**, wherein the spring-type contact is a cantilever contact.

6. The electrical connector of claim **1**, wherein the spring is located in the hinge, forming a spring-loaded hinge.

7. The electrical connector of claim **1**, wherein the spring comprises a pair of linear springs between the top and bottom plates on either side of the hinge perpendicularly connected to the top and bottom plates.

8. The electrical connector of claim **1**, wherein the top plate comprises a top locking feature.

9. The electrical connector of claim **1**, wherein the bottom plate comprises a bottom locking feature.

10. The electrical connector of claim **1**, wherein the bottom plate comprises a stopping feature.

11. An electronic assembly, comprising:

a package comprising a die electrically coupled to a substrate, the substrate comprising a diving board that protrudes from an edge of the substrate;

an electrical connector electrically coupled to the substrate through the diving board, the electrical connector comprising:

a top plate, a bottom plate, an array of contacts on at least one of the top plate and bottom plate, a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate, and a spring applying a force against the top and bottom plates; and

a cable electrically coupled to the electrical connector, the electrical connector is electrically coupled to the substrate.

12. The electronic assembly of claim **11**, wherein the substrate is a package substrate.

13. The electronic assembly of claim **12**, wherein the diving board comprises an array of pads, each pad of the array of pads does not extend to an edge of the diving board.

14. The electronic assembly of claim **13**, wherein the edge of the diving board contacts a stopping feature on the electrical connector.

15. The electronic assembly of claim **11**, wherein the diving board comprises a locking key.

16. The electronic assembly of claim **15**, wherein the locking key is a notch formed at an edge of the diving board into which a locking feature on the electrical connector fits.

17. The electronic assembly of claim **11**, wherein the cable is a flex cable.

18. The electronic assembly of claim **17**, wherein the flex cable comprises an array of contacts on a first end of the flex cable.

19. The electronic assembly of claim **18**, further comprising a compliant mattress disposed behind the array of contacts and between the flex cable and at least one of the top and bottom plate.

20. A method of forming an electronic assembly, comprising:

providing a package comprising a die electrically coupled to a substrate, the substrate comprising a diving board that protrudes from an edge of the substrate;

providing an electrical connector comprising:

a top plate, a bottom plate, an array of contacts on at least one of the top plate and bottom plate, a hinge between the top plate and the bottom plate, the hinge mechanically connecting the top plate to the bottom plate, and a spring applying a force against the top and bottom plates;

applying force upon a non-engaging region of the electrical connector;

aligning the electrical connector and the diving board to one another; and

removing the force, causing electrical coupling between the electrical connector and the substrate.

21. The method of claim **20**, wherein the array of contacts do not travel on the substrate.

22. The method of claim **20**, wherein applying the force causes an engaging end of the electrical connector to open.

23. The method of claim **20**, wherein electrical coupling is created by a closing force generated by a spring in the electrical connector.

24. The method of claim **20**, wherein aligning the electrical connector includes inserting a locking feature into a locking key.

25. The method of claim **20**, wherein aligning the electrical connector includes the substrate contacting a stopping feature on the electrical connector.

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